FORM PTO-1390 (Modified) (REV 11-2000) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER
TRANSMITTAL LETTER TO THE UNITED STATES	**219604US2PCT**
DESIGNATED/ELECTED OFFICE (DO/EO/US)	U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR
CONCERNING A FILING UNDER 35 U.S.C. 371	**10/049910**

INTERNATIONAL APPLICATION NO. **PCT/FR00/02306**	INTERNATIONAL FILING DATE **11 August 2000**	PRIORITY DATE CLAIMED **20 August 1999**

TITLE OF INVENTION
ABRASION-RESISTANT READ HEAD

APPLICANT(S) FOR DO/EO/US
JACQUET Jean-Claude

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.

2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.

3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include itens (5), (6), (9) and (24) indicated below.

4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).

5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))

    a. ☐ is attached hereto (required only if not communicated by the International Bureau).

    b. ☒ has been communicated by the International Bureau.

    c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).

6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).

    a. ☒ is attached hereto.

    b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).

7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))

    a. ☐ are attached hereto (required only if not communicated by the International Bureau).

    b. ☐ have been communicated by the International Bureau.

    c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.

    d. ☒ have not been made and will not be made.

8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).

9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).

10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

11. ☒ A copy of the International Preliminary Examination Report (PCT/IPEA/409).

12. ☒ A copy of the International Search Report (PCT/ISA/210).

Items 13 to 20 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.

14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

15. ☒ A **FIRST** preliminary amendment.

16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.

17. ☐ A substitute specification.

18. ☐ A change of power of attorney and/or address letter.

19. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.

20. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).

21. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).

22. ☐ Certificate of Mailing by Express Mail

23. ☒ Other items or information:

    Request for Priority/Form PTO-1449
    PCT/IB/304/Drawings (7 sheets)
    PCT/IB/308
    Cited References (1)

     PCTUS1/REV03

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 10/049910	INTERNATIONAL APPLICATION NO. PCT/FR00/02306	ATTORNEY'S DOCKET NUMBER 219604US2PCT

24. The following fees are submitted:.

CALCULATIONS PTO USE ONLY

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1040.00**

☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$890.00**

☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$740.00**

☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$710.00**

☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**

ENTER APPROPRIATE BASIC FEE AMOUNT = | **$890.00** |

Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)). | **$0.00** |

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	17 - 20 =	0	x $18.00	$0.00	
Independent claims	1 - 3 =	0	x $84.00	$0.00	
Multiple Dependent Claims (check if applicable).			☐	$0.00	

TOTAL OF ABOVE CALCULATIONS = $890.00

☐ Applicant claims small entity status. See 37 CFR 1.27). The fees indicated above are reduced by 1/2. | **$0.00** |

SUBTOTAL = $890.00

Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). + | **$0.00** |

TOTAL NATIONAL FEE = $890.00

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable).** ☐ | **$0.00** |

TOTAL FEES ENCLOSED = $890.00

Amount to be: refunded	$
charged	$

a. ☒ A check in the amount of **$890.00** to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **15-0030** A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING: Information on this form may become public. Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Surinder Sachar
Registration No. 34,423

22850

_____
SIGNATURE

Marvin J. Spivak
_____
NAME

24,913
_____
REGISTRATION NUMBER

Feb. 20 2002
_____
DATE

219604US-154-154-2-PCT

<u>IN THE UNITED STATES PATENT & TRADEMARK OFFICE</u>

IN RE APPLICATION OF: :

JEAN-CLAUDE JACQUET   : ATTN: APPLICATION DIVISION

SERIAL NO: NEW U.S. APPLICATION   :
  (Based on PCT NO:FR00/02306)

FILED: HEREWITH   : EXAMINER:

FOR: ABRASION-RESISTANT READ HEAD

<u>PRELIMINARY AMENDMENT</u>

ASSISTANT COMMISSIONER FOR PATENTS
WASHINGTON, D.C.   20231

SIR:

Please amend the above-identified application as follows:

<u>IN THE CLAIMS</u>

Please cancel Claims 1-17 without prejudice.

Please add new Claims 18-34 as follows:

18. (New) A magnetooptic read head, comprising:

a magnetooptic transducer with a multilayer structure with at least one thin magnetic

layer with a magnetooptic effect;

at least one layer of a nonmagnetic material and having a predetermined wear

coefficient greater than that of the multilayer structure; and

a layer with good magnetic permeability for closing a magnetic circuit, and

wherein the layer with good magnetic permeability comprises alternating first

sublayers made of a magnetic material with good magnetic permeability and second sublayers

made of a material having a wear coefficient substantially equivalent to said wear coefficient of the layer made of a nonmagnetic material.

19. (New) The read head as claimed in claim 18, wherein the first sublayers are made of a material similar to that of the thin magnetic layer with a magnetooptic effect.

20. (New) The read head as claimed in claim 18, wherein the second sublayers are made of a material similar to that of the layer made of a nonmagnetic material.

21. (New) The read head as claimed in claim 19, wherein the layer with a magnetooptic effect is made of a material based on iron, silicon and aluminum ($Fe_xSi_yAl_z$) or based on iron, tantalum and nitrogen ($Fe_xTa_yN_z$).

22. (New) The read head as claimed in claim 20, wherein the layer made of a nonmagnetic material is made of a material based on silicon and nitrogen (Si_xN_y).

23. (New) The read head as claimed in claim 18, wherein a thickness of the first sublayers is less than a diameter of the particles coming from wear of the materials of the read head or of a medium to be read.

24. (New) The read head as claimed in claim 23, wherein a thickness of the first sublayers is between 10 and 50 nm.

25. (New) The read head as claimed in claim 24, wherein a thickness of the second sublayers is a few tens of nanometers.

26. (New) The read head as claimed in claim 25, comprising a few tens of first sublayers that alternate with a few tens of second sublayers.

27. (New) The read head as claimed in claim 18, further comprising a reflecting layer located between the nonmagnetic layer and the layer of good magnetic permeability.

28. (New) The read head as claimed in claim 27, wherein the reflecting layer is made of gold or of copper.

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29. (New) The read head as claimed in claim 18, further comprising a layer of an optical coupling material placed against the layer with a magnetooptic effect.

30. (New) The read head as claimed in claim 29, wherein the optical coupling layer is made of silicon.

31. (New) The read head as claimed in claim 18, wherein the layer of good magnetic permeability is coated with a protective layer on its face that faces away from the layer of a nonmagnetic material.

32. (New) The read head as claimed in claim 31, wherein the protective layer is made of Si_xN_y.

33. (New) The read head as claimed in claim 18, further comprising a backplate adhesively bonded to the layer of good magnetic permeability or to the protective layer.

34. (New) The read head as claimed in claim 33, wherein the layer with a magnetooptic effect is supported by a substrate, a sidewall of a stack of layers comprising:

    a substrate;

    a layer with a magnetic effect;

    a layer with good magnetic permeability;

    a backplate,

the stack of layers forming an active face of the magnetic head and a thicknesses of the backplate and of the substrate measured on said sidewall are substantially equal.

IN THE ABSTRACT

Please cancel the original Abstract page 23 in its entirety and insert therefor:

ABSTRACT

A magnetooptic read head including a magnetooptic transducer with a multilayer structure with at least one thin magnetic layer with a magnetooptic effect, at least one layer made of a nonmagnetic material and having a predetermined wear coefficient, and a layer with good magnetic permeability for closing a magnetic circuit. The layer with good magnetic permeability includes alternating first sublayers made of a magnetic material with good magnetic permeability and second sublayers made of a material having a wear coefficient substantially equivalent to the wear coefficient of the layer made of a nonmagnetic material.

<u>REMARKS</u>

Favorable consideration of this application, as presently amended, is respectfully requested.

The present preliminary amendment is submitted to place the above-identified application in more proper format under United States practice.

By the present preliminary amendment original Claims 1-17 are cancelled and new Claims 18-34 are presented for examination. New Claims 18-34 are deemed to be self-evident from the original disclosure, including original Claims 1-17, and thus are not deemed to raise any issues of new matter. Further, new Claims 18-34 are not believed to be more narrow than original Claims 1-17 in any aspect.

A new Abstract believed to be in more proper format is also submitted herein.

The present application is believed to be in condition for a full and thorough examination on the merits. An early and favorable consideration of the present application is hereby respectfully requested.

Respectfully submitted,

OBLON, SPIVAK, McCLELLAND,
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- 5 -

Marked-Up Copy
Serial No: _____
Amendment Filed on:
_____2-20-2002

IN THE CLAIMS

Claims 1-17 (Cancelled).

Claims 18-34 (New).

IN THE ABSTRACT

Abstract (New).

7 PRTS

ABRASION-RESISTANT READ HEAD

The present invention relates to a magnetooptic read
head.

5

To read a magnetic medium, a known type of magnetooptic
head uses a Faraday effect and/or a Kerr effect. These
effects consist in magnetizing a magnetooptic material,
such as garnet, by the magnetic flux produced by the

10 magnetic medium, and in detecting this magnetization by
means of the rotational power it has on polarized
light.

The physical principle exploited is the magnetooptic

15 effect known by the name of Kerr rotation or Faraday
rotation. In this effect, the polarization state of an
electromagnetic wave reflected from a magnetooptic
medium or passing through it, is modified. This state
depends on the direction of magnetization of the

20 medium. Since the read pole consists of a material of
this type, the polarization of a laser beam reflected
therefrom is altered by the variations of magnetization
induced by the magnetic medium. This modulation is then
transformed into variations of light intensity which

25 are then measured using a photodetector thus making it
possible to reconstruct the information written on the
magnetic medium. Therefore the magnetic information is
no longer carried by an electric current but by an
electromagnetic wave.

30

A read head of this type has been described in French
patent No. 2 656 723. Figure 1 shows the simplified
diagram of one embodiment of this head.

35 It comprises a layer 9 of magnetic material with good
magnetic permeability, of a thickness which can reach
several microns, for example.

A layer 10 of nonmagnetic material, of a thickness for

example between 50 and 3 000 nm, and typically about
300 nm, and a thin layer 11 of magnetic material
forming the layer with a magnetooptic effect (Kerr
effect for example) are formed on the layer 9. The
5   thickness of the layer 11 is, for example, between
about 10 and 200 nm. An oblique incident optical beam
12 arrives on the layer 11, which reflects a beam 13.
The layers 9 to 11 are polished on one of their sides,
for example perpendicularly to their main surface, and
10   the magnetic tape 14 to be read is applied to the
surface polished in this way.

The head of figure 1 may be easily produced in a single
layer deposition operation, and it is not absolutely
15   necessary to etch the deposited layers in order to
produce multitrack read heads.

Figure 2 shows a multitrack magnetooptic read system 20
comprising a read head according to the invention. The
20   main benefit of using a Kerr effect head for reading a
multitrack recording is due to the principle of active
reading, the performance of which is not disadvantaged
by a low play speed of the tape to be read. Upstream of
the Kerr effect head 21, the system 20 comprises a
25   point light source 22, preferably a laser diode, a
collimating objective 23, a device 24 comprising a
polarizer serving to make the polarization of the light
beam passing through it perpendicular to the direction
of movement of the tape 25 to be read, and a
30   cylindrical lens 26 oriented so as to focus the beam
collimated by the objective 23 along a line
perpendicular to the direction of movement of the tape
25.

35   The head 21 comprises, as stated in the present
description, a Kerr effect sensor and, as necessary, an
optical reflector.

Downstream of the head 21, the system 20 comprises an optical imaging device 27; a device 28 comprising an analyzer and, where necessary, a phase compensator; and a linear optical sensor 29, the active zone of which is the optical conjugate, by means of the optical system, of the line illuminated on the Kerr effect head. This optical sensor comprises, for example, a CCD linear array. Since the magnification of the downstream part of the system 20 is typically about one, it is possible advantageously to produce it in integrated optics.

Figure 3 shows one embodiment of a magnetooptic read head according to the invention in which the various layers of figure 1 are produced on a prism 35 made of a material transparent to the wavelength of the read beam. This material is, for example, made of GGG (galidonium gallium garnet). The various faces 30 to 33 of this prism are oriented such that the read beam 12 penetrates without reflection into the prism and is reflected on the face 32 bearing the magnetooptic layer 11 of the head, near to the read zone of the magnetic tape 14 to be read. The exit face 33 is oriented such that the beam 13 exits without reflection from the prism. It should be noted that the faces 30 and 33 may be coated with a layer of antireflective material made of SiO_2 for example.

The layers 9, 10, 11 correspond to the layers bearing the same references in figure 1 are made on the face 32 of the prism.

In this type of known magnetic head, the magnetooptic layer 11 is made of sendust ($Fe_xSi_yAl_z$), the airgap layer 10 is made of Si_3N_4 or Al_2O_3 and the magnetic layer 9 is made of sendust.

By way of example, at the present time, a magnetooptic read head may consist of a stack of the following materials:

- a sendust layer 11, with a thickness of 30 nm and which acts as a read pole,
- a silicon nitride layer with a thickness of 180 nm,
5 - a copper layer with a thickness of 50 nm

these two layers acting as a magnetic and optical airgap layer 10.

10 - a sendust layer 9 with a thickness of 1 μm making it possible to close the flux and acting as magnetic shielding,
- a layer of alumina or of Si_3N_4 or of any other hard nonmagnetic material with a thickness of
15 2 μm can be provided to protect the assembly.

All of this is deposited on a garnet substrate.

These materials of a very different nature all have
20 different mechanical properties. Thus, we have a combination of hard materials (garnet, Si_3N_4, Al_2O_3) and of soft materials (sendust, copper). This construction of materials with very different hardnesses is extremely penalizing in terms of component service
25 life. This is because, on contact with the tape, we observe a phenomenon of differential wear between the hard and soft materials with the appearance of a recess of about 100 nm in the less hard materials, this recess being mainly located on the layer 9 (see figure 4a).
30 This wear is shown in figures 4a and 4b. Where the layer 9 is covered with a layer 10b of hardness greater than that of the layer 9, wear of the sort shown in figure 4b may occur. This wear may be substantial at the end of only a few hundred hours of use, while it is
35 desired to have from 5 000 to 30 000 hours of operation depending on the intended application. This recess results in a signal loss of about 6 dB at 1 μm of electromagnetic wavelength due to the space created and the loss of resolution, the head passing progressively

from bipolar operation where the resolution is determined by the gap width to monopolar operation where the resolution is then determined by the extent of the active zone of the read pole.

5

It is then impossible to recover the signal, the part in contact being irreparably damaged and only reforming the flat would allow this signal to be recovered.

10 In magnetoresistive read/write heads, the current solutions propose depositing a layer of a hard material on the front of the head. However, this solution is demanding and expensive in terms of technical production (the hard materials being difficult to 15 produce), and generates space losses of about 3 to 4 dB at 1 μm (for 60 nm deposited).

The invention aims to solve this wear problem.

20 The invention therefore relates to a magnetooptic read head, characterized by the fact that it comprises a magnetooptic transducer with a multilayer structure with at least one thin magnetic layer with a magnetooptic effect, at least one layer of a 25 nonmagnetic material and having a predetermined wear coefficient and a layer with good magnetic permeability for closing a magnetic circuit, and in that the layer with good magnetic permeability comprises alternating first sublayers made of a magnetic material with good 30 magnetic permeability and second sublayers made of a material having a wear coefficient substantially equivalent to said wear coefficient of the layer made of a nonmagnetic material.

35 The various objects and characteristics of the invention will become more clearly apparent in the following description provided by way of example and in the appended figures which show:

- figures 1 to 4, magnetooptic read heads according to the prior art and described above;
- figure 5, a simplified example of a magnetooptic read head according to the invention;
- figure 6, an exemplary embodiment of the various layers of the read head of figure 5;
- figures 7a and 7b, a more complete example of a read head according to the invention;
- figures 8 to 11, an embodiment of the read head enabling the head structure to be made symmetric.

A simplified example of a magnetooptic read head according to the invention will first of all be described with reference to figure 5.

This read head comprises, as described above, a layer 11 made of a material having magnetooptic properties (Kerr effect and/or Faraday effect), an airgap layer 10 made of a nonmagnetic material, a layer 90 made of a magnetic material having good magnetic permeability in order to allow the magnetic flux induced by the magnetic medium 14 to flow and to be closed by the layers 11 and 9.

According to the invention, the layer 9 consists of a stack of sublayers (such as 91, 93) made of a material with good magnetic permeability alternating with sublayers (such as 92, 94) having a wear coefficient substantially equivalent to that of the airgap layer 10. Preferably, this wear coefficient is small.

Preferably, the sublayers made of a material with good magnetic permeability are made of a material similar to that of the layer 11. The sublayers made of a material with a wear coefficient equivalent to that of the layer 10 are made of a material similar to that of the airgap layer 10.

In this way, the layers 9 and 10 will wear uniformly and the wear phenomenon of figure 4 will not occur.

Figure 6 shows an exemplary embodiment of a read head of this type. According to this example, the layer 11 is made of sendust ($Fe_xSi_yAl_z$) with a thickness of about 25 nm, the airgap layer 10 is made of silicon nitride (Si_xN_y) with a thickness of about 200 nm and the layer 9 consists of alternating layers of sendust of 30 nm thickness and of layers of silicon nitride of 20 nm thickness. For example, the layer 9 may consist of about thirty layers of sendust and about thirty layers of silicon nitride.

It will therefore be seen that, according to the invention, in order to reduce the problems of shrinkage of the second pole (layer 9), we start from the observation that the value thereof depends on the thickness of the magnetic material, the shrinkage decreasing as the thickness decreases. Thus, the smaller the thickness of the material in contact with the tape, the more the wear of this material will be reduced. This explains why the layer 11 is much less affected by this phenomenon, its thickness of 20 nm (compared to 1.5 μm) being less than the mean size of the abrasive particles, and acts as a filter for the abrasive particles transported by the tape. We therefore propose to produce the second pole by alternating a material of a hardness comparable with the substrate (such as Si_3N_4 for example), with magnetic layers of a thickness x which are small enough to sufficiently reduce this differential wear to an acceptable level. In this way we produce, on the scale of abrasive phenomena, a mechanically hard magnetic material. The number of periods n is defined such that the product nx is equal to the thickness of magnetic materials needed in order that the second pole can continue to fulfill its role of closing the flux and of magnetic shielding.

The choice of materials is not limiting (instead of $Fe_xSi_yAl_z$ in particular, this could be $Fe_xTa_yN_z$ or any other magnetic material).

5   Under these conditions, the invention intends that preferably the thickness of the softest material (sendust) is less than the mean size of the abrasive particles due to the roughness of the tape and to the dust generated by the latter. The hardness of the

10   material thus produced will be that of the hardest material. Only the particles of a size less than this thickness will be able to tear matter from the soft material. Furthermore, the depth which will be hollowed out will be about this thickness.

15

The various thicknesses s and n to be given to the two materials of the layer 9 (sendust and Si_3N_4) will be the compromise which will allow the shrinkage of the layer 9 to be reduced sufficiently without altering the

20   magnetic properties required for the layer 9 and which will allow correct operation of the system.

The latter will then simultaneously have good magnetic properties (high saturation magnetization, low coercive

25   field, well controlled anisotropy, etc.) and a hardness or abrasion resistance greater than that of the basic magnetic material. In this way, we combine the mechanical hardness properties of Si_3N_4 with the magnetic property of sendust and produce a material

30   whose resistance to abrasion phenomena can be set by varying the relative thicknesses of the two materials present (up to a possible 5 nm for the magnetic material).

35   Furthermore, as is shown in figure 6, the read head may have additional characteristics.

In particular, the magnetooptic layer 11 can be produced on a substrate 60 made of GGG with an

intermediate adhesive layer 61. Furthermore, a reflective layer 63 may be provided between the airgap layer 10 and the assembly 9 of alternating layers 9, the light of the read beam not all being reflected by the layer 11. A purpose of this reflective layer is to increase the reflection of the fraction of the beam having passed through this read pole. The index of the airgap layer is chosen such that the reflected beams are superimposed while being in phase.

Finally, a protective layer 64 of a few micrometers thickness made of silicon nitride is provided on the layer stack 9.

By way of example, a detailed embodiment corresponding to figure 7 makes it possible to obtain a read head, the various layers of which have the following characteristics:

- substrate 60: made of GGG
- adhesive layer 61: made of Al_2O_3, 2.5 nm thickness
- magnetooptic layer 11: made of sendust, 25 nm thickness
- airgap layer 10: made of Si_xN_y, of index n between 2 and 3.5 and of 200 nm thickness
- adhesive layer 62: made of sendust, 2.5 nm thickness
- reflective layer 63: made of copper or of gold, 50 nm thickness
- magnetic layer 9: stack of a few tens (30 for example) of layers of sendust (thickness between 10 and 50 nm, for example 30 nm) alternating with a few tens (30 for example) of layers of Si_xN_y of a few tens of nm, 20 nm for example
- protective layer 64 made of Si_xN_y with a thickness of a few µm (1 to 5).

We will now describe an exemplary manufacturing method of a read head of this sort. This method comprises the following three main phases:

- the deposition of the various magnetic, dielectric and reflective layers, which make it possible to produce the magnetic head and the Fabry-Perot resonant optical structure;
- the deposition of the protective Si_3N_4 layer of a few μm thickness (1 to 5) which is followed by annealing in the magnetic fields of the layers;
- the cutting, the polishing and the antireflective and protective treatments of the various faces of the prism forming the component.

In the present technology, all the layers are deposited by sputtering in a chamber whose vacuum pressure is about a few tens of nanotorr. This chamber makes it possible to produce Coatings by DC and RF, magnetron and diode sputtering, it being possible to produce these coatings in a magnetic field. The targets have a diameter of 100 mm and the coating distance is 15 cm which makes it possible to deposit layers whose thickness has a homogeneity of about 2 to 3% on wafers with diameters of 2 inches.

The choice of substrate on which the coatings are produced is important. Its position as optical (coupling of light in the read pole) and mechanical (contact with the tape) interface and the role of radiator that it must provide (removal of heat deposited by the laser source) impose a number of restrictions on the physical properties. These restrictions are:

- to transmit a maximum of light to the read pole and to the photodetector, therefore to be transparent to the laser wavelength used;

- not to modify the polarization state of the electromagnetic wave when it passes through the substrate therefore to be slightly birefringent;
- to efficiently remove the heat resulting from the absorption, by the magnetooptic medium, of the incident electromagnetic wave and which degrade the magnetic properties of the read layer, therefore to be a good heat conductor;
- to prevent the flat wearing too quickly, therefore to be hard enough;
- to be easily machinable and to have a chemical-mechanical resistance compatible with the conditions of use of the system.

All of these restrictions may lead to choosing a substrate made in a single crystal of the garnet family, for example a garnet of generic formula $Gd_3Ga_5O_{12}$.

The coatings are produced on substrates, the two faces of which are already polished. These faces have a roughness of about 5 Å. The substrates are 2 inches in diameter and have a thickness of 3 mm. There are also substrates of 3 inches diameter which have the same physical characteristics, particularly with regard to the homogeneity of the optical properties.

Before carrying out the coating sequence, the substrate should be cleaned. The various cleaning stages are as follows:

The substrate is immersed in three successive solutions of trichloroethylene, acetone and propanol. Each of these immersions lasts for 3 minutes. The immersions are at a temperature of 60°C and are agitated by ultrasound. After this chemical-mechanical cleaning, the substrate is introduced into the coating chamber. Inside the chamber, before starting to deposit the layers, we carry out a final cleaning by plasma

etching. We can then launch the sequence for depositing various layers forming the stack.

The deposition method starts by depositing an aluminum layer of 2.5 nm thickness. The role of this layer is to provide adherence for the following layer on the substrate.

The first magnetic pole (layer 11), called a read pole and off which the laser beam is reflected, is then deposited. The material used to produce this layer is sendust, its thickness is 25 nm. This layer has a dual function: on the one hand, it must efficiently sense the magnetic field generated by the tape, on the other hand, it must convert the magnetic variations as efficiently as possible into polarization variations. This layer must therefore possess correct magnetic properties and have as high a magnetooptic coefficient as possible. The deposition conditions and the chemical composition of the material therefore have to be suitable to meet these requirements.

Next, a dielectric layer and a reflective layer of copper or of gold are deposited. This set of layers also has a dual function. Not only must it act as a magnetic gap, but also as a Fabry-Perot resonant optical structure, the role of this structure being to improve the coupling of the incident wave ·with the magnetooptic layer and to recover the Faraday rotation generated as the electromagnetic wave passes through this layer. Thus, the physical and geometrical characteristics of these two layers define the read density and the quality of resonance. Careful choice of the indexes and of the thicknesses of the various layers makes the optimum adjustment of these two parameters possible. In the case of a head having to reread 0.4 micron bits, for a laser wave of 780 nanometers with an angle of incidence of 45°, the dielectric layer must have a thickness of 1900 Å and a

refractive index close to 2, it being possible for the reflector to be a copper or gold layer of · 500 Å thickness. The dielectric layer is produced from a silicon target, the deposition being carried out in the

5   presence of a mixture of nitrogen and of argon. In this way, we obtain a compound close to silicon nitride, the silicon and nitrogen proportions of which depend mainly on the nitrogen concentration.

10   Next comes the deposition of the second pole (layer 9) making it possible to close the flux and also acting as a magnetic shield. The material used is the same as that of the read pole because of its magnetic properties.

15

This second pole consists of a stack of 30 periods of 30 nm of sendust and of 20 nm of silicon nitride. As well as increasing the deposition time, this structure makes it possible to reduce the shrinkage of this pole

20   during passage of the tape. This second pole 9 is therefore made of an artificial material combining the magnetic properties of the sendust and the abrasion-resistant properties of the silicon nitride.

25   Next, an Si_3N_4 layer of about a few micrometers' thickness whose role is to protect all of the coatings, is deposited. All of this is then introduced into an annealing furnace in a magnetic field making it possible to improve the magnetic properties of the

30   component (decrease the coercive field and induce magnetic anisotropy in the read and flux closure poles).

Next come the various steps of cutting and of polishing

35   the prisms. We start by cutting the substrate into bars of 5 mm width then we procede to polishing the various faces B, D corresponding respectively to the faces for exit and for total reflection of the beam, then we produce the flat M by polishing on abrasive strips.

Figures 7a, 7b show a variant embodiment of the invention in which a backplate 66 is provided in order to ensure correct contact of the read layers (9, 10, 11) with the tape. This backplate may be adhesively bonded to the magnetic layer 11 or to the protective layer 10b.

In this way, a stack of layers, as shown in Figure 7a, is obtained, which makes it possible to produce, for example, the read head of figure 7b.

The role of this backplate, which can be considered as a second substrate, is, on the one hand, to increase the width of the flat in contact with the tape, on the other hand, to locate the layers 9, 10, 11 of the head in the center of the active face (flat M), reducing the rate of wear of the flat M and simplifying the positioning and holding of the head on the medium, as will be explained below.

We will now explain the function of the backplate 66.

This backplate makes it possible to produce a geometry of the flat which makes it possible to improve the contact and the adjustment of the head on the magnetic tape and to considerably reduce the manufacturing constraints bearing on the tolerances of that part of the read head in contact with the tape.

In the present heads, the main parameters and elements characterizing the contact of the head with the magnetic tape are as follows (figures 8a to 8c):

For the system:

- the wrap angle a, of about 0.5°,
- the distance 2D separating the guides, about 10 mm,

- the insertion h of the head in the tape, about 50 μm,
- the tension T of the tape.

5   For the flat:

- the width C, about 100 μm,
- the radius of curvature R about 5 mm,
- its composition, which consists of materials of
10   different thickness and hardness,
- the position of the active zone of the head on the flat, the shielding/closure of the flux and read poles being at distances d2 and d1 of 3 and to 5 μm from the edge of the flat, respectively.
15

Its various parameters are not independent and are linked by the following equations:

h = Da
20   C = 2Ra

Given the constraints linked to the size of the system (parameter D), to the production of the flat (parameters R and C), and to the quality of the contact
25   (parameters a and h), the values given above are a good compromise (D, a and h).

However, this geometry has the following major drawbacks:
30

- relating to the contact:

One of the first problems is linked to the fact that the magnetic layers are at the end (figure 1c) of the
35   flat. This device makes the positioning of the head on the tape (parameters h, D and w) critical and imposes strict tolerances on the manufacture of the flat (parameters R and C).

Let us evaluate these restrictions. Let us calculate firstly the range of value in which the insertion h of the head in the tape must be located in order for there to be contact. In figures 9a-9b, we see that if the

5 insertion h is not enough, there will be no contact with the active zone, on the other hand, if it is too much, the tape' will protrude over the edges of the flat, the pressure then exerted by the tape will be much higher in the contact zone which will lead to

10 accelerated wear of the portion of the flat in contact with the tape. Thus, the last point of contact Cd, Cd1 and Cd2 between the tape and the flat must be between the points C1 and C2, this defines two contact widths of the tape with the flat, that is C and C-2 d2. The

15 insertion h associated with this range is calculated easily using the above formulae and we obtain:

$$h = CD/2R \ (1-d2/C) \pm Dd2/2R = h_{med} \pm h_{int}$$

20 h_{med} is the nominal value of the insertion, h_{int} is the margin of adjustment over this insertion and must be less than the uncertainties in adjustment and manufacture. Let us evaluate these various uncertainties.

25

- uncertainty in manufacture of the flat:

$$h_{fab} = CD/2R \ (Ri/R + Ci/C)$$

30 - uncertainty in positioning the head:

- laterally: h_{lat}: CD/2R Di/D
- angularly: $h_{ang} = D \ wi$
- insertion: h_{iz}

35

that is: $h_{pos} = CD/2R \ Di/D + h_{iz} + D \ wi$

We therefore obtain the following equation:

CD/2R Di/D + h_{iz} + D wi + CD/2R (Ri/R + Ci/C)<Dd2/2R

with the above data, we obtain h_{int} = 1.5 μm

If we assume that we are capable of guaranteeing slopes at close to 1% for the flat, (which corresponds to a tolerance of 50 μm on the radius of curvature and of 1 μm on the width), we obtain a value for h_{fab} of 1 μm, which means that it is necessary to guarantee the positioning of the head at 0.5 μm, which is extremely difficult to obtain. In practice, it is tolerable for there to be a space z between the head and the tape. This space introduces a loss p of the signal, the expression in dB for which is:

$$p = 55 \ z/Im = 55 \ d^2/R/Im \text{ that is } d = V(p \ R \ Im/55)$$

where d is the distance from the last point of the tape in contact with the flat and Im the electromagnetic wavelength of the signal to be read, the values being given in microns.

If we accept a loss of 1 dB on the signal read at 0.8 μm, we obtain d = 8.5 μm. The adjustment margin h_{int} is then 5 μm. In spite of that, in order to be in the desired operating zone, it must be possible to reposition the head with an accuracy of insertion of 1 μm and over the azimuth of 2' and to keep the tape in front of the active part of the head in the same zone of variation (h_{tape}<1 μm) as it passes, which requires accurate and therefore expensive mechanisms.

We therefore see that in this geometry, to produce a correct contact with the tape will result in high manufacturing costs of the component and in improved mechanisms, even though a loss of 1 dB on the signal is tolerated.

According to the invention, in order to relax the manufacturing and positioning constraints of the head, the position of the active layers is made symmetric with respect to the edges of the flat (figure 10). We achieve this by adhesively bonding a backplate 66 of the same type as the substrate 60 onto the layers. In figure 10, we can see that the adjustment margin h_{int} can be chosen so as to make the constraints bearing on the accuracy of the adjustment of the head with respect to the tape and on the tolerances for producing the flat as small as necessary. For example, for a flat of 1500 μm, whose contact surface with the tape is between 500 μm and 1100 μm, we obtain an adjustment margin h_{int} on the insertion of ± 150 μm, and this without loss of signal and without the tape rubbing on the edge of the flat, which also makes it possible to relax the quality of polishing in this zone (bearable glare).

According to a variant embodiment of the read head according to the invention, it is possible to insert between the substrate 60 and the magnetooptic layer 11, a silicon layer making it possible to improve the coupling of the read beam in the magnetooptic layer 11. Experimentally, a doubling of the merit factor of the read head is noted, making it possible for the read rate to increase by a factor of four. This improvement can be applied per se to a magnetooptic read head independently of the rest of the invention. Similarly, the invention could be applied to a magnetooptic medium in which the magnetooptic layer would be produced on a silicon layer.

According to another variant, in order to maximize the magnetooptic merit factor as a function of the size of the airgap of the read head, the value of the refractive index of the airgap 10 material can be adjusted by varying the concentration of nitrogen during sputtering, making it possible to set the magnetooptic resonance peak over the deposited

thickness. It is thus possible to make the index of the airgap layer vary continuously between 3.7 and 2, the material passing progressively from the silicon composition alone to silicon nitride.

5

CLAIMS

1. A magnetooptic read head, characterized by the fact that it comprises a magnetooptic transducer with a multilayer structure (9 to 11) with at least one thin magnetic layer with a magnetooptic effect (11), at least one layer of a nonmagnetic material (10) and having a predetermined wear coefficient greater than that of 9 and a layer with good magnetic permeability (9) for closing a magnetic circuit, and in that the layer with good magnetic permeability comprises alternating first sublayers (91, 93) made of a magnetic material with good magnetic permeability and second sublayers (92, 94) made of a material having a wear coefficient substantially equivalent to said wear coefficient of the layer made of a nonmagnetic material (10).

2. The read head as claimed in claim 1, characterized in that the first sublayers (91, 93) are made of a material similar to that of the thin magnetic layer with a magnetooptic effect (11).

3. The read head as claimed in claim 1, characterized in that the second sublayers (92, 94) are made of a material similar to that of the layer made of a nonmagnetic material (10).

4. The read head as claimed in claim 2, characterized in that the layer with a magnetooptic effect (11) is made of a material based on iron, silicon and aluminum ($Fe_xSi_yAl_z$) or based on iron, tantalum and nitrogen ($Fe_xTa_yN_z$).

5. The read head as claimed in claim 3, characterized in that the layer made of a nonmagnetic material (10) is made of a material based on silicon and nitrogen (Si_xN_y).

6.   The read head as claimed in claim 1, characterized
in that the thickness of the first sublayers is less
than the diameter of the particles coming from wear of
the materials of the read head or of a medium to be
5   read.

7.   The read head as claimed in claim 6, characterized
in that the thickness of the first sublayers is between
10 and 50 nm.
10

8.   The read head as claimed in claim 7, characterized
in that the thickness of the second sublayers is a few
tens of nanometers.

15   9.   The read head as claimed in claim 8, characterized
in that it comprises a few tens of first sublayers
which alternate with a few tens of second sublayers.

10.   The read head as claimed in claim 1, characterized
20   in that it comprises a reflecting layer (63) located
between the nonmagnetic layer (10) and the layer of
good magnetic permeability (11).

11.   The read head as claimed in claim 10,
25   characterized in that the reflecting layer is made of
gold or of copper.

12.   The read head as claimed in claim 1, characterized
in that it comprises a layer of an optical coupling
30   material placed against the layer with a magnetooptic
effect (11).

13.   The read head as claimed in claim 12,
characterized in that the optical coupling layer is
35   made of silicon.

14.   The read head as claimed in claim 1, characterized
in that the layer of good magnetic permeability (9) is
coated with a protective layer (64) on its face which

faces away from the layer of a nonmagnetic material (10).

15. The read head as claimed in claim 14, characterized in that the protective layer (64) is made of Si_xN_y.

16. The read head as claimed in either of claims 1 and 14, characterized in that it comprises a backplate (66) adhesively bonded to the layer of good magnetic permeability (9) or to the protective layer (64).

17. The read head as claimed in claim 16, characterized in that the layer with a magnetooptic effect (11) is supported by a substrate (60), the sidewall of a stack of layers especially comprising:
  • a substrate (60);
  • a layer with a magnetic effect (10);
  • a layer with good magnetic permeability (9);
  • a backplate (66)

forms the active face of the magnetic head and in that the thicknesses of the backplate (66) and of the substrate (60) measured on said sidewall are substantially equal.

ABSTRACT

ABRASION-RESISTANT READ HEAD

Magnetooptic read head comprising a magnetooptic transducer with a multilayer structure (9 to 11) with at least one thin magnetic layer with a magnetooptic effect (11), at least one layer made of a nonmagnetic material (10) and having a predetermined wear coefficient and a layer with good magnetic permeability (9) for closing a magnetic circuit. The layer with good magnetic permeability comprises alternating first sublayers (91, 93) made of a magnetic material with good magnetic permeability and second sublayers (92, 94) made of a material having a wear coefficient substantially equivalent to said wear coefficient of the layer made of a nonmagnetic material (10).

FIGURE 5
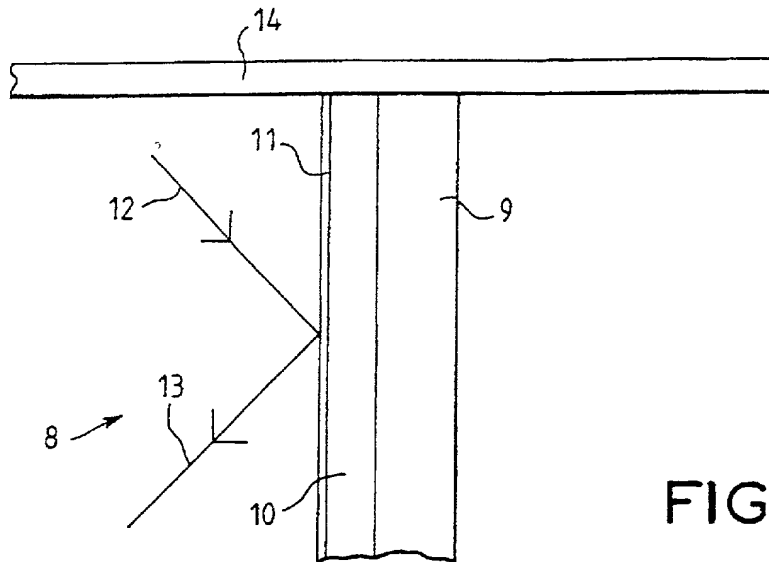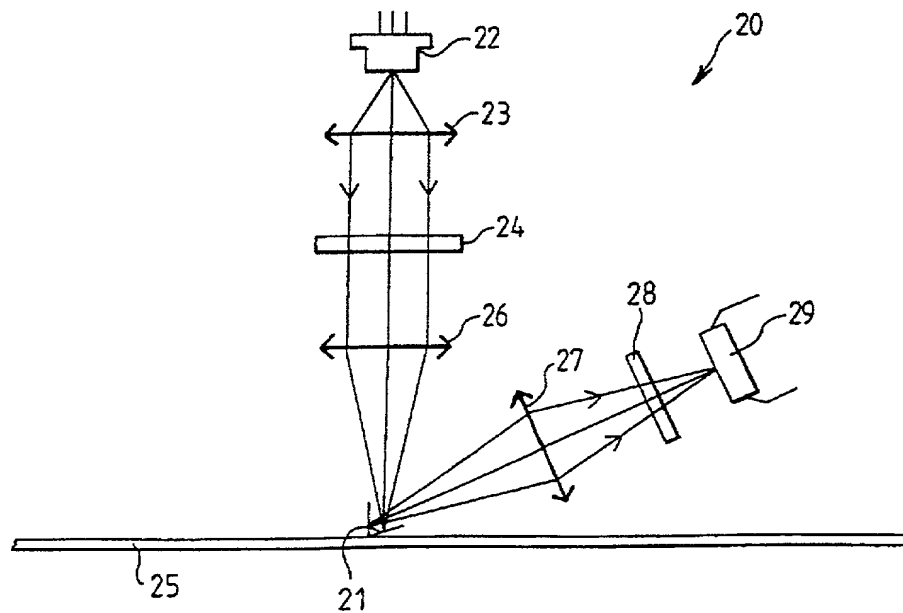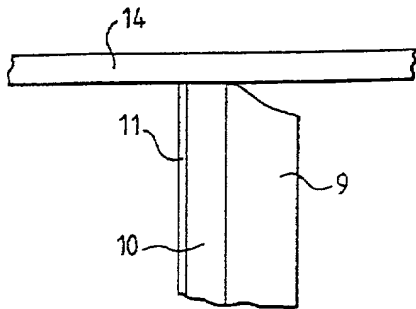
FIG.1

FIG.2

FIG.3

FIG.4a

FIG.4b

3/7

FIG.5

FIG.6

66
65
ADHESIVE
64
$\simeq 30 \times [$SENDUST $(300$ Å$)/$Si$_3$N$_4(200$ Å$)]$
OR $1 \times$ SENDUST $(9000$ Å$)$
63
SENDUST $(25$ Å$)$
62
ADHESIVE
11
Al$_2$O$_3$ $(25$ Å$)$
61
ADHESIVE
60

9
Cu OR Au
$(500$ Å$)$
10
Si$_x$N$_y$ $(n = 3,7$ to $2)$

FIG.7a

FIG.7b

FIG.8a

FIG.8b

FIG.8c

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INSUFFICIENT INSERTION (1) = Cd1

Cd2

Cd1

14

TOO MUCH INSERTION (2) = Cd2

FIG.9a

14

C_2

Z

C_1

HEAD
INSUFFICIENTLY
INSERTED

FIG.9b

11   10   9

14

66

60

FIG.10

2hint

$C1$ $C1$

$C2$ $C2$ 14

UPPER
INSERTION
LIMIT

hmed

HEAD NOT INSERTED

LOWER INSERTION LIMIT
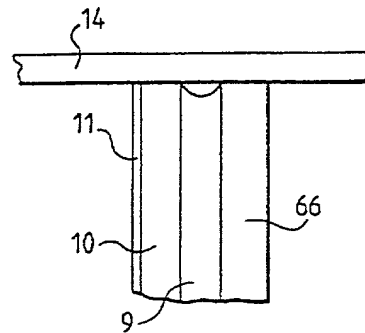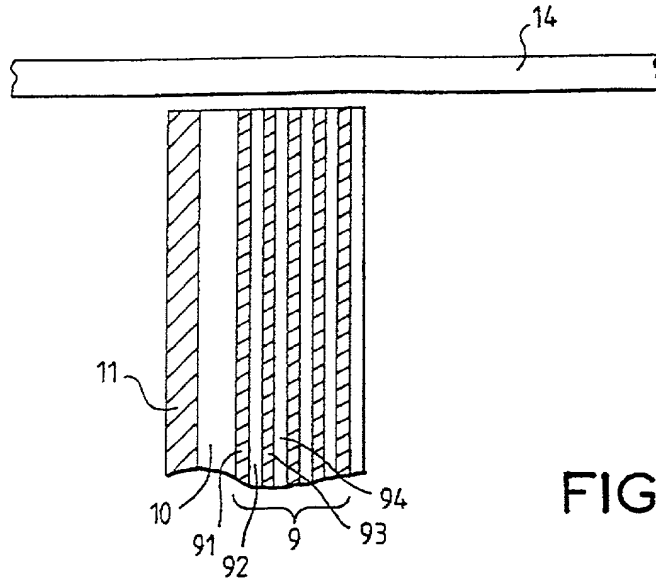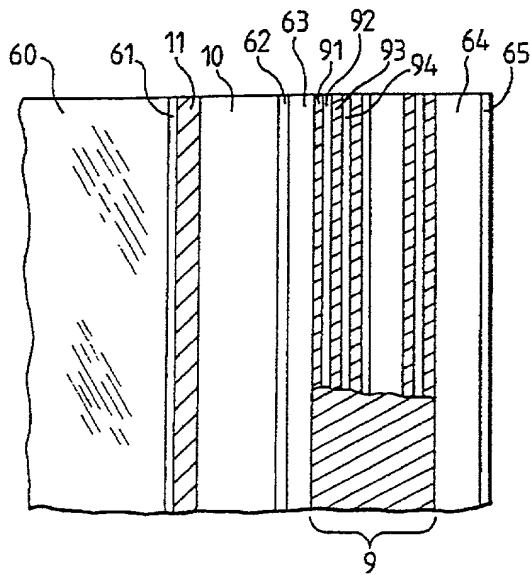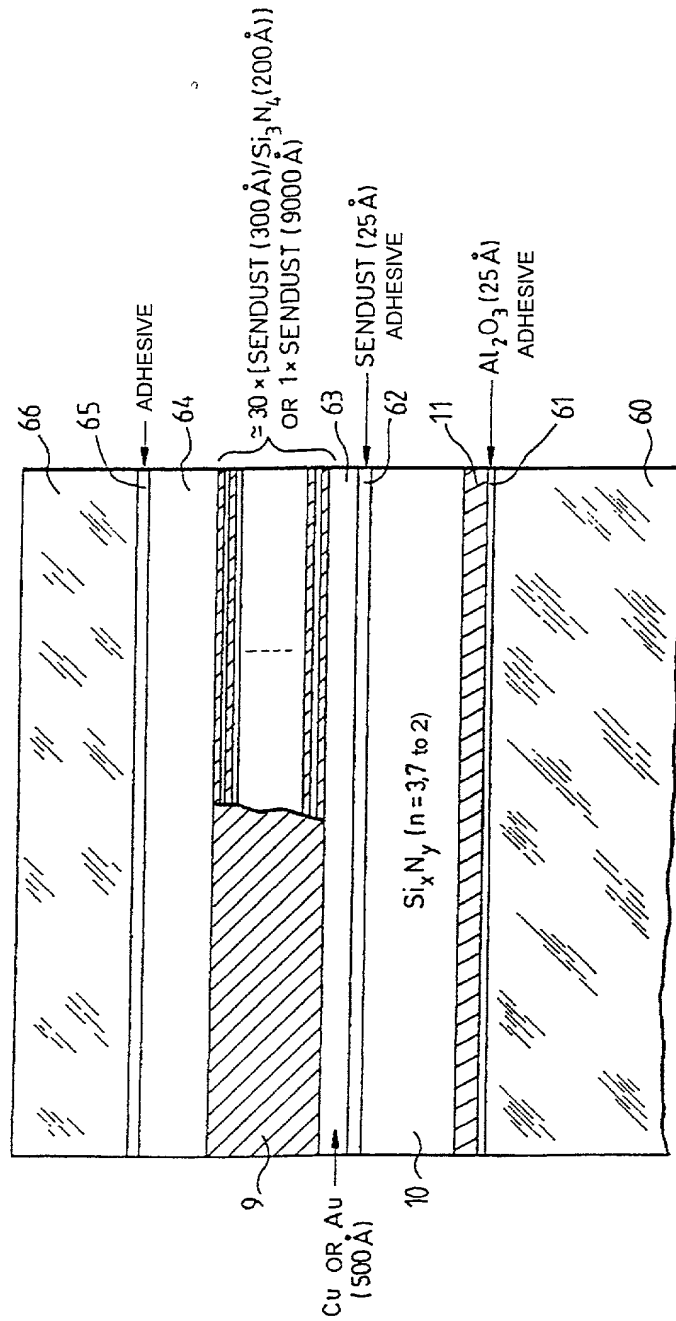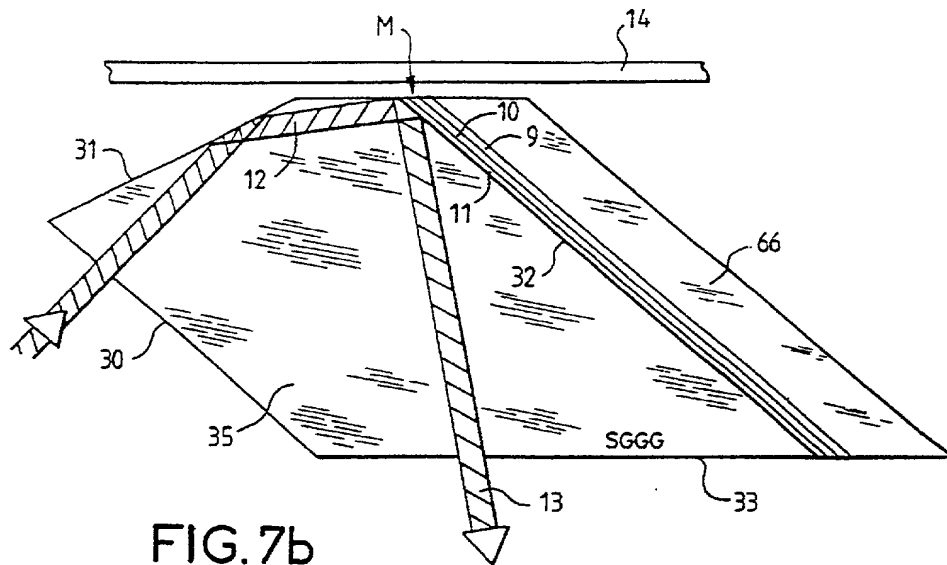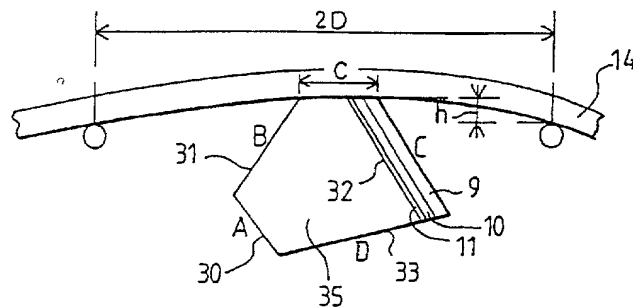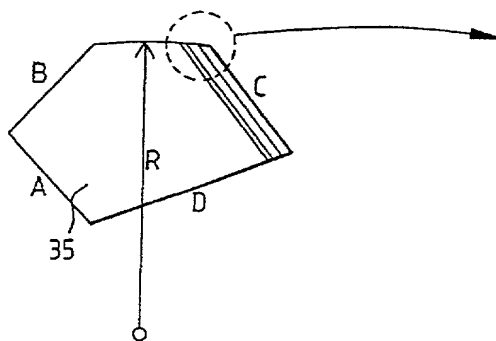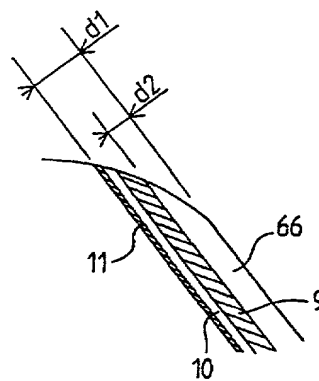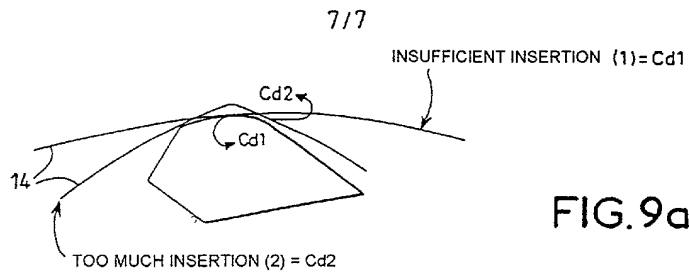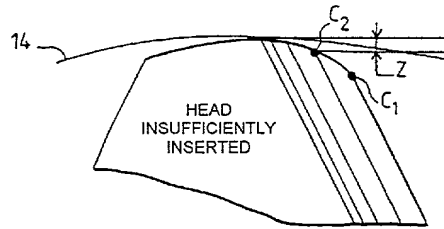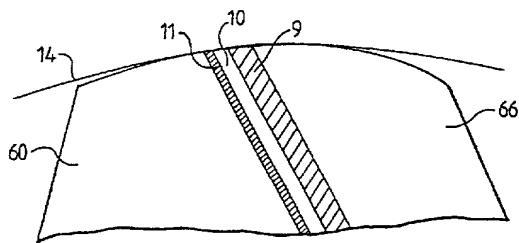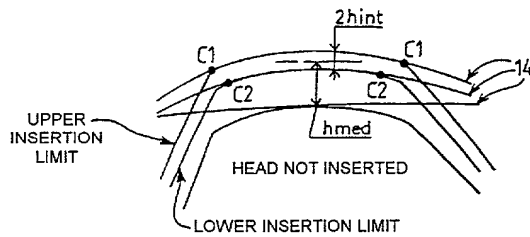
FIG.11

Declaration and Power of Attorney for Patent Application
Déclaration et Pouvoirs pour Demande de Brevet
French Language Declaration

En tant l'inventeur nommé ci-après, je déclare par le présent acte que:

As a below named inventor, I hereby declare that:

Mon domicile, mon adresse postale et ma nationalité sont ceux figurant ci-dessous à côté de mon nom.

My residence, mailing address and citizenship are as stated next to my name.

Je crois être le premier inventeur original et unique (si un seul nom est mentionné ci-dessous), ou l'un des premiers co-inventeurs originaux (si plusieurs noms sont mentionnés ci-dessous) de l'objet revendiqué, pour lequel une demande de brevet a été déposée concernant l'invention intitulée

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled.

ABRASION-RESISTANT READ HEAD

et dont la description est fournie ci-joint

the specification of which

☐ ci-joint

☐ a été déposée le _____

sous le numéro de demande des Etats-Unis ou le numéro de demande international PCT

☐ is attached hereto.

☒ was filed on __**August 11, 2000**__

as United States Application Number or PCT International Application Number

_____ et modifiée le

(le cas échéant).

__**PCT/FR00/02306**__ and was amended on

_____ (if applicable)

Je déclare par le présent acte avoir passé en revue et compris le contenu de la description ci-dessus, revendications comprises, telles que modifiées par toute modification dont il aura été fait référence ci-dessus.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

Je reconnais devoir divulguer toute information pertinente à la brevetabilité, comme défini dans le Titre 37, § 1.56 du Code fédéral des réglementations.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56.

French Language Declaration

Je revendique par le présent acte avoir la priorité étrangère, en vertu du Titre 35, § 119(a)-(d) ou § 365(b) du Code des Etats-Unis, sur toute demande étrangère de brevet ou certificat d'inventeur ou, en vertu du Titre 35, § 365(a) du même Code, sur toute demande internationale PCT désignant au moins un pays autre que les Etats-Unis et figurant ci-dessous et, en cochant la case, j'ai aussi indiqué ci-dessous toute demande étrangère de brevet, tout certificat d'inventeur ou toute demande internationale PCT ayant une date de dépôt précédant celle de la demande à propos de laquelle une priorité est revendiquée.

I hereby claim foreign priority under Title 35, United States Code, § 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)
Demande(s) de brevet anterieure(s) dans un autre pays.

			Priority Claimed Droit de priorité Revendiqué

__99 10671__	__FRANCE__	__20 AUGUST 1999__	☒ Yes Oui	☐ No Non
(Number) (Numéro)	(Country) (Pays)	(Day/Month/Year Filed) (Jour/Mois/Anné de dépôt)		
(Number) (Numéro)	(Country) (Pays)	(Day/Month/Year Filed) (Jour/Mois/Anné de dépôt)	☐ Yes Oui	☐ No Non

Je revendique par le présent acte tout bénéfice, en vertu du Titre 35, § 119(e) du Code des Etats-Unis, de toute demande de brevet provisoire effectuée aux Etats-Unis et figurant ci-dessous.

I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below.

(Application No.) (Nº de demande)	(Filing Date) (Date de dépôt)	(Application No.) (Nº de demande)	(Filing Date) (Date de dépôt)

Je revendique par le présent acte tout bénéfice, en vertu du Titre 35, § 120 du Code des Etats-Unis, de toute demande de brevet effectuée aux Etats-Unis, ou en vertu du Titre 35, § 365(c) du même Code, de toute demande internationale PCT désignant les Etats-Unis et figurant ci-dessous et, dans la mesure où l'objet de chacune des revendications de cette demande de brevet n'est pas divulgué dans la demande antérieure américaine ou internationale PCT, en vertu des dispositions du premier paragraphe du Titre 35, § 112 du Code des Etats-Unis, je reconnais devoir divulguer toute information pertinente à la brevetabilité, comme défini dans le Titre 37, § 1.56 du Code fédéral des réglementations, dont j'ai pu disposer entre la date de dépôt de la demande antérieure et la date de dépôt de la demande nationale ou internationale PCT de la présente demande:

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s), or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

__PCT/FR00/02306__	__August 11, 2000__	
(Application No.) (Nº de demande)	(Filing Date) (Date de dépôt)	(Status: Patented, Pending, Abandoned) (Statut : breveté, en cours d'examen, abandonné)
(Application No.) (Nº de demande)	(Filing Date) (Date de dépôt)	(Status: Patented, Pending, Abandoned) (Statut : breveté, en cours d'examen, abandonné)

Je déclare par le présent acte que toute déclaration ci-incluse est, à ma connaissance, véridique et que toute déclaration formulée à partir de renseignements ou de suppositions est tenue pour véridique; et de plus, que toutes ces déclarations ont été formulées en sachant que toute fausse déclaration volontaire ou son équivalent est passible d'une amende ou d' une incarcération, ou des deux, en vertu de la § 1001 du Titre 18 du Code des Etats-Unis, et que de telles déclarations volontairement fausses risquent de compromettre la validité de la demande de brevet ou du brevet délivré à partir de celle-ci.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

French Language Declaration

POUVOIRS: En tant qu'inventeur cité, je désigne par la présente l'(les) avocat(s) suivant(s) pour qu'ils poursuive(nt) la procédure de cette demande de brevet et traite(nt) toute affaire s'y rapportant avec l'Office des brevets et des marquees: *(mentionner le nom et le numéro d'enregistrement)*.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: (list name and registration number)

022850

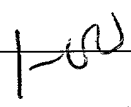Addresser toute correspondance à:

Send Correspondence to:

022850

Adresser tout appel téléphonique à: (nom et numéro de téléphone)

Direct Telephone calls to: (name and telephone number)

(703) 413-3000

Nom complet de l'unique ou premier inventeur		Full name of sole or first inventor Jean-Claude JACQUET - 4 FEV. 2002	
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Nom complet du second co-inventeur, le cas echeant		Full name of second joint inventor, If any	
Signature de l'inventeur	Date	Second inventor's signature	Date
Domicile		Residence	
Nationalité		Citizenship	
Adresse Postale		Mailing Address	

(Fournir les mêmes renseignements et la signature du troisième co-inventeur et de tout co-inventeur supplémentaire.)

(Supply similar information and signature for third and subsequent joint inventors.)